A Novel Approach Based on DEMATEL Method for Causal Modeling an Effective Factors in Falling from Height Accidents in Construction Projects

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ABSTRACT
Falling from height known as one of the most important factors that leads to fatal accidents in the construction industry. The purpose of this study was to investigate and identify the effective factors in the occurrence of falling from height accidents in the construction projects and determine the causal relationships between organizational, individual and environmental factors.
In this research, the surveyed population was the workers of five construction projects of a gas refinery in south of Iran from 2011 to 2015. Using the Integrated Management System (IMS) information, factors and sub-factors affecting the occurrence of falling from height accidents in the construction projects were determined. Then, a semi-comparative questionnaire based on the DEMATEL technique was designed and distributed among 10 experts at two different periods. Based on the expert's opinions, the identified factors and sub-factors were classified into three main factors and fourteen sub-factors, respectively. Then, the causal relationships between each the effective factor were identified, using DEMATEL technique.
The results of DEMATEL technique revealed that the individual factors were considered to be the most important criteria, as it has acquired the maximum $(D + R)$ value, i.e., 36.689 whereas, organizational factors had scored the least, i.e., 35.180. Accordingly, organizational factors and their sub-factors had a substantial effect on the falling from height accidents and were considered as causal variables (D-R>0), while, the indices of individual and environmental factors were the effect variables (D-R<0). So that, mutual understanding was an organizational sub-factor that had the highest impact on the occurrence of falling from height and has been identified as a causal variable.
Generally, it is necessary to consider specific plans such as stress management and safety culture programs in order to reduce unsafe conditions in the construction projects.
Keywords: Falling from Height, DEMATEL Technique, Construction Projects.

INTRODUCTION
The International Labor Organization (ILO) estimates that there exist 2.3 million work-related cases of fatal accidents and illnesses, 160 million non-fatal illnesses and 317 million nonfatal occupational injuries around the globe [1]. Work-related accidents are the third cause of death in the world and the second in Iran after traffic accidents [2]. Occupational accidents in the construction industry are more common in comparison with other fields [3,4]. Construction workers are at higher risk of injuries than other industries due to the dynamic nature of construction activities as well as the instant changes in the working conditions [5,6]. Work-related injuries and mortalities resulting from the construction projects not only lead to the loss of human life and its quality but also delay the process of the project and impose financial losses on employers and workers. Mortalities in the construction industries add billions of dollars to the direct costs, leading to serious injuries and ten days of missed work on average [7]. Whilst, indirect costs are estimated to be 6 times greater than the direct costs [8,9]. In a study carried out by Hatipkarasulu on maritime contractors, falling from height is introduced as the most important factor that attributed to death, followed by getting stuck, collision with objects, and cardiac attacks [10]. Bunn *et al.* stated that falling from height has the highest rate of compensation for the injured workers in the construction industry, where its related cost has made it as the most costly incident in this industry [11]. Also, it has been identified as the most costly incident in many countries [8,12]. As a result, controlling and preventing falling from height

accidents are the matter of international concern in the construction industry [12]. Based on a study carried out by Jiang Min *et al*. in 2012 on the Chinese construction projects, personal, organizational and environmental factors were identified as influential factors in this industry [13].

After the Chernobyl devastating accident, organizational factors have attracted the attention of many researchers to the safety issues. Recent safety theories have considered organizational factors as the hidden cause of accidents in industries. In addition, organizational factors have been recognized as an important indicator of safety in the industries, and hence investigating on them is vital to prevent future accidents [14]. Organizational factors which affect the safe performance of the individuals are classified into four categories: organizational, safety management, workgroup, and individual levels. Organizational factors can be influenced by external environmental factors such as economic, social and technical characteristics along with national culture. Therefore, organizational factors may have different effects on the safe performance of the individuals in different countries [15,16].

Most researchers have suggested that occupational injuries and accidents occur as a result of three main factors, namely unsafe acts, unsafe conditions and unpredictable causes [17]. So that, the unsafe behaviour of employees is one of the main and direct causes of occupational accidents [18–21], and more recent studies have contributed 76% of all accidents to the individual factors and 20% to both individual and environmental factors [22].

Hu *et al.* considered attitudes and behaviours of workers as extremely influential factors in the falling from height accidents. He also described other effective factors on the falling from height accidents as follows: safe performance of contractors, use of personal protective equipment, physical conditions of workers, workplace conditions, organization size, and workplace height [12].

DEMATEL technique is based on the assumption that a system contains a set of criteria and a pairwise comparison of the relationships between these criteria can be modelled by mathematical equations. DEMATEL is an approach to identify and understand the cause and effect relationships among several factors [23–25]. Assuming that n factors affect the system, a method should be created to measure the severity of the cause and effect relationships between these factors. For this purpose, the measurement levels are divided into four levels and are identified by 0, 1, 2, and 3, which indicate the lack of communication, effectiveness, high level of effectiveness, and very high level of effectiveness, respectively [26].

The main cause of the most occupational hazards is unsafe conditions and activities, where could be prevented and managed if they are understood by subjects [17]. Therefore, understanding the causes of work-related injuries and mortalities in the construction industry can help to set strategies and priorities for preventing accidents [27]. In this paper, while investigating and identifying the factors affecting the falling from height accidents in the construction projects, the cause and effect relationships between the organizational, individual and environmental factors and their sub-factors are determined.

MATERIALS AND METHODS

In this descriptive study, the surveyed population was the workers of five construction projects of a gas refinery in south of Iran. On average, 4000 people were involved in these projects from 2011 to 2015. Using the Integrated Management System (IMS) information, factors and sub-factors affecting the occurrence of falling from height accidents in the construction projects were determined. Then a semi-comparative questionnaire based on the DEMATEL technique was designed and distributed among 10 faculty members and health and safety experts in two different periods with a two-week break in order to prove the reliability of the test. For this aim, the correlation coefficient between the first course with the second course was obtained 0.90, using Spearman correlation coefficient. The probability of excluding a variable is approximately zero in the questionnaire of the experts. Since all effective factors (listed below) are taken into consideration in this study, the questions will be posed without any bias. Therefore, this questionnaire is valid [28]. In what follows, the step-by-step processes of this research are explained below.

Step 1: Identifying research factors and sub-factors

The study was initiated by scrutinizing different kinds of the scientific literature, project reports, and guidelines and then proceeded to use available information of the occupational health and safety unit of the selected construction projects. All events occurred from 2011 to 2015 were investigated and 74 of these occupational accidents were falling from height accidents. Seventy factors and sub-factors were identified based on the integrated information of the occupational health and safety units of the projects as well as the reviewed studies about the falling from height accidents [29–31]. Then, the collected factors based on the safety experts and managers' viewpoint were examined. Based on this examination, the identified factors and sub-factors were divided into 3 main factors and 14 sub-factors, respectively (Table 1).

Table 1: Key effective factors

Main factors	Sub-factors
Organizational factors	**Management commitment:** Management commitment is one of the key elements of the organizations' success in the competitive domains [32]. It is also one of the main factors of the safety status and is a subset of the organizational factors. Several studies have confirmed its implications for occurrence of unsafe behaviour and occupational accidents [33,34]. **Safety culture:** Safety culture is a set of beliefs, norms, motivations, roles and social and technical functions that reduces the confrontation between employees, managers and stakeholders and dangerous conditions [35]. **Mutual understanding:** It is known as one of the sub-factors that affects the safety climate and behaviour of employees in each organization. The main concept behind the mutual understanding is paying more attention and hearing the problems and conflicts of safety in the organization [36]. **Supervision/Inspection:** Effective inspection of the OHS department is one of the promising tools in preventing accidents. Internal and external monitoring and inspection have a significant relationship with implementation of the safe activities [37]. **Size of the organization/project:** The size of the project is a descriptive parameter that many researchers have already studied on it. The implementation cost of the project is considered as a basis for such a comparison [38].
Individual factors	**Education:** There is a significant relationship between education level and accidents occurrence, where decreasing education level of individuals will increase the accident frequency rate. **Training hours:** Occupational injuries and casualties occur at workplace every day, often due to the lack of employees training on how to do the job properly. The main purpose of training is that the staff must learn how to do the work and why it should be done. It is necessary to consider proportional and periodic safety training according to the occupation and personnel features. **Personal protective equipment:** In many studies, the lack of utility of protective equipment is introduced as one of the main reasons in occurrence of accidents [39]. **Age/experience:** Age is one of the factors that can affect individual activities in the workplace [40]. **Psychological/Occupational stresses:** Studies on unsafe behaviours have demonstrated that the stressful occupational factors contribute significantly to unsafe behaviours by reducing concentration, distraction, memory impairment, hesitation in doing duties, and decision-making power. In the same way, the results of studies have proven the role of job stressors factors in construction accidents [37].
Environmental factors	**Thermal stresses:** Thermal stresses are a serious risk in many industrial environments, affecting the health and performance of individuals [41]. **Interference:** Interference between different work situations sometimes caused by the presence of two executives from two different companies with management interferences. This will make it possible for workers who are unfamiliar with doing work and the dangers associated with their tasks. Interference arises due to a lack of the order of doing an activity and any hurry to do these activities. **Level smooth:** The purpose of the level smooth is to identify the lack of housekeeping on the workplace platform. In many cases, the falling is due to the lack of individual's attention for discipline of the workplace safety which results in the collapse of personal balance [42]. **Work platform height:** Work platform height is one of the most important parameters in falling from height, which has been studied by many researchers. Huang and Hinze recommended that more attention is need to pay to workers who work at an altitude of more than 30 ft. (9 meters) due to the high accident rate in the construction industry [43].

Step 2: Data analysis by DEMATEL technique

During the research, the factors and sub-factors are named by numerical indices in order to be easily studied and understood (Table 2). The results of this technique operation is performed by step-by-step approach throughout this study as follows [25,26]:

Step 1- Calculation of the direct relation matrix (M): At first, a group of experts investigated the relationship between sets of factors based on the paired comparison scale. For this purpose, the measurement of the relationship between factors *i* and *j* requires that the comparison scale to be constructed according to the following four influential levels: no influence (0), low influence (1), medium influence (2), high influence (3), and very high influence (4). The integer score X_{ij}^{k} is given by the *K*th expert and indicates the influential level that factor *i* has on factor *j*. The $n \times n$ average matrix M is derived by averaging individual expert's scores in Eq. (1).

$$m_{ij} = \frac{1}{H}\sum_{k=1}^{H} X_{ij}^{k} \qquad (1)$$

Where *H* is the total number of experts.

Step 2-Calculation of the normal direct-relation matrix (N): The sum of all rows and columns was computed and then the inverse of the maximum number is formed (K). Then, all components of M are multiplied by the K, so that the normal matrix is obtained (Eq. 2).

$$k = \frac{1}{\max \sum_{j=1}^{n} a_{ij}} \qquad (2)$$

$$\mathrm{N} = \mathrm{K} \times \mathrm{M} \qquad (3)$$

It should be mentioned that the sum of each row *j* of matrix *N* represents the direct effects that factor *i* gives to the other factors.

Step 3- Calculation of the total-relation matrix (T): Once the normalized direct-relation matrix is obtained, the total-relation matrix T can be calculated. For this purpose, the normal matrix (N) is subtracted from the identity matrix (I) and the results are reversed. Finally, the result is multiplied by the normal matrix as follows:

$$T = N \times (I - N)^{-1} \qquad (4)$$

Step 4- Calculation of the threshold intensity value and display of the network relationships map: To determine the network relationship map (NRM), the threshold intensity should be calculated. The threshold value was computed by averaging components of the total-relation matrix. Once this threshold value was calculated, only the effects greater than the threshold value was chosen as a significant effect and shown in digraph. At this step, D and R vectors were calculated, representing the sum of rows and columns of the total-relation matrix, respectively. Once D and R vectors were calculated, a diagram can be acquired by mapping the data set of D+R versus D–R. The horizontal axis vector (D+R) is called "Prominence", which indicates the importance of the factor. Similarly, the vertical axis (D-R) is called "Relation", which may divide factor into a cause group and effect group. Generally, when (D-R) is positive, the factor belongs to the cause group. Otherwise, if (D-R) is negative, the factor belongs to the effect group.

Table 2: Criteria and sub-criteria of research

Symbol	Criteria	Symbol	Sub-criteria
C1	Individual factors	SS1	Education
		SS2	Training hours
		SS3	PPE
		SS4	Age/experience
		SS5	Psychological/Occupational stress
C2	Organizational factors	SS6	Management commitment
		SS7	Culture of safety
		SS8	Understanding
		SS9	Supervision/Inspection
		SS10	Organization size/Project size
C3	Environmental factors	SS11	Thermal stress
		SS12	Interference
		SS13	Smooth surface
		SS14	Work platform heights

RESULT

Calculation of the direct relation matrix

The direct-relation matrix was obtained based on the simple account average of experts' viewpoints (Table 3). Each element of X_{ij} represents the magnitude of the effect of factor i on factor j. The elements on the main diameter of this matrix are zero, which means that the factors do not directly affect themselves (X_{ij}=0).

Calculation of the normal direct-relation matrix

The sum of all rows and columns was computed and then the inverse of the maximum number was named K. Based on Table 3, the maximum number was 4.8 and all values of this table were multiplied by the K. As a result, the following normal direct-relation matrix was obtained (Table 4).

Table 3: Initial direct matrix *M*

Criteria	Individual factors	Organizational factors	Environmental factors	Sum of rows
Individual factors	0	2.2	2.35	4.55
Organizational factors	2.3	0	2.35	4.65
Environmental factors	2.5	1.95	0	4.45
Sum of Columns	4.8	4.15	4.7	

Table 4: Normal direct relation matrix N

Matrix N	Individual factors	Organizational factors	Environmental factors
Individual factors	0.000	0.458	0.490
Organizational factors	0.479	0.000	0.490
Environmental factors	0.520	0.406	0.000

Calculation of the total-correlation matrix

Table 5 shows the total-correlation matrix (T) for main factors.

Calculation of the threshold intensity value and display of the network relationships map

In this study, the threshold intensity was obtained 6.0 by averaging the components of the total-relation matrix, where a significant relationship pattern was observed (Table 6). In this table, all zero values indicate that there were no cause and effect relationships between the factors.

Based on Table 7, individual factors are considered to be the most important criteria, as it has acquired the maximum $(D + R)$ value, i.e., 36.689 whereas, organizational factors have scored the least, i.e., 35.180. Generally, the ranking of the main criteria can be done by $(D + R)$ values (Fig. 1). Similarly, the values in (D-R) help to separate the criteria into cause and effect groups based on their obtained values (Fig. 2).

In general, if D-R was positive, the variable will be a causal variable and if it was negative, it will be considered an effect variable. Accordingly, the indices of individual and environmental factors were the effect variables, while the indices of the organizational factors considered as causal variables (Table 7).

Table 5: Total influential relation matrix ***T***

Matrix T	Individual factors	Organizational factors	Environmental factors
Individual factors	6.007	5.749	6.245
Organizational factors	6.422	5.517	6.334
Environmental factors	6.259	5.642	5.826

Table 6: The pattern of casual relationships map for main factors

Matrix T	Individual factors	Organizational factors	Environmental factors
Individual factors	6.007	0	6.245
Organizational factors	6.422	0	6.334
Environmental factors	6.259	0	0

Table 7: The casual diagram for main factors

Matrix T	D	R	D+R	D-R
Individual factors	18.001	18.688	36.689	-0.686
Organizational factors	18.273	16.907	35.180	1.366
Environmental factors	17.726	18.406	36.132	-0.680

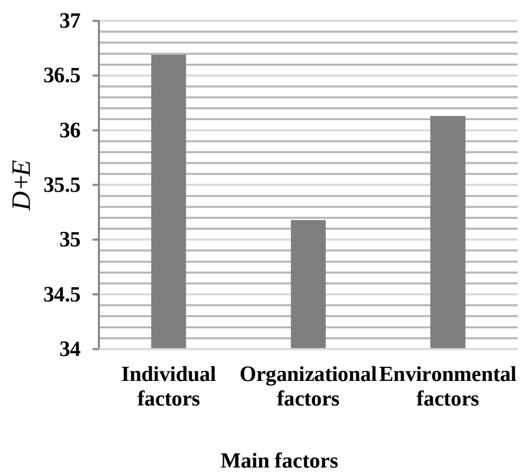

Fig 1: Prominence graph of main factors

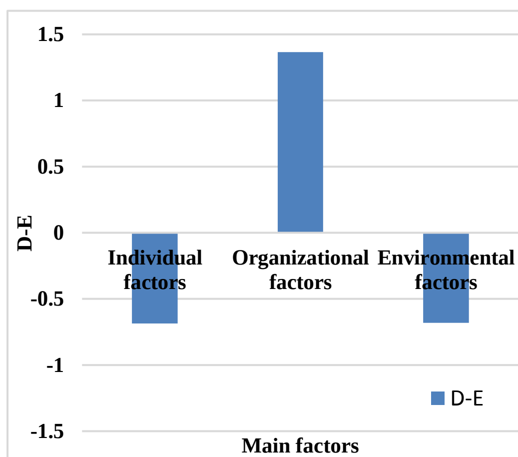

Fig 2: Net cause and effect graph of main factors.

Identification of the internal relations between sub-factors

In this research, relations between the sub-factors were also examined based on mentioned four scale levels. For this purpose, the direct-relation matrix between the sub-factors was formed and then an average matrix is derived by averaging individual expert's scores. The internal relation matrix between the sub-factors is shown in Table 8.

After calculating the total-relation matrix, the total threshold value was computed 0.449. Then, a pattern of meaningful relationships was obtained based on the sub-factors relations (Table 9).

According to Fig. 3 it can be concluded that four out of five organizational sub-factors, including mutual understanding, management commitment, safety culture and organization/project size and two out of five individual sub-factors, including training hours and psychological/occupational stress have the most impact and were among the causal variables, whereas the rest of sub-factors were the effect variables. Also, according to Table 9 and Fig. 4, the monitoring/inspection sub-factor has the most interaction with other sub-factors. Moreover, this sub-factor has the most impact on other sub-factors (Fig. 4).

Table 8: The internal relation matrix between the sub-factors

Matrix	ss1	ss2	ss3	ss4	ss5	ss6	ss7	ss8	ss9	ss10	ss11	ss12	ss13	ss14
ss1	0.402	0.429	0.465	0.430	0.425	0.441	0.424	0.450	0.514	0.446	0.418	0.449	0.461	0.402
ss2	0.468	0.370	0.468	0.428	0.441	0.464	0.421	0.438	0.513	0.456	0.416	0.449	0.463	0.410
ss3	0.464	0.424	0.410	0.419	0.428	0.456	0.444	0.442	0.514	0.448	0.423	0.440	0.463	0.418
ss4	0.366	0.339	0.377	0.295	0.344	0.348	0.347	0.345	0.420	0.360	0.337	0.347	0.367	0.335
ss5	0.537	0.482	0.545	0.479	0.419	0.522	0.499	0.512	0.566	0.510	0.473	0.492	0.514	0.470
ss6	0.537	0.479	0.541	0.481	0.470	0.439	0.481	0.491	0.578	0.519	0.472	0.502	0.522	0.465
ss7	0.469	0.425	0.501	0.441	0.441	0.454	0.381	0.459	0.515	0.466	0.438	0.445	0.475	0.422
ss8	0.534	0.477	0.526	0.480	0.478	0.511	0.478	0.426	0.573	0.510	0.472	0.499	0.520	0.453
ss9	0.545	0.497	0.550	0.494	0.493	0.511	0.489	0.487	0.509	0.517	0.494	0.521	0.540	0.474
ss10	0.508	0.469	0.516	0.471	0.466	0.496	0.466	0.471	0.561	0.427	0.460	0.486	0.499	0.441
ss11	0.424	0.387	0.438	0.385	0.389	0.412	0.402	0.403	0.470	0.410	0.333	0.396	0.423	0.385
ss12	0.439	0.400	0.423	0.402	0.398	0.419	0.392	0.410	0.483	0.406	0.384	0.353	0.427	0.388
ss13	0.468	0.432	0.471	0.426	0.422	0.452	0.428	0.443	0.520	0.442	0.411	0.428	0.396	0.406
ss14	0.433	0.396	0.443	0.406	0.420	0.431	0.414	0.424	0.490	0.423	0.408	0.411	0.426	0.338

Table 9: The casual relations between the sub-factors

Sub-factors	Symbol	D	R	D+R	D-R
Education	ss1	6.155	6.594	12.749	-0.439
Training hours	ss2	6.206	6.008	12.214	0.198
PPE	ss3	6.195	6.674	12.869	-0.480
Age/Experience	ss4	4.926	6.036	10.963	-1.110
Psychological/Occupational stress	ss5	7.019	6.035	13.054	0.983
Management commitment	ss6	6.978	6.357	13.335	0.622
Safety culture	ss7	6.333	6.067	12.399	0.266
Mutual Understanding	ss8	6.939	6.201	13.140	0.738
Supervision/Inspection	ss9	7.119	7.226	14.345	-0.107
Organization size/Project size	ss10	6.738	6.339	13.077	0.399
Thermal stress	ss11	5.656	5.939	11.594	-0.283
Interference	ss12	5.724	6.217	11.941	-0.493
Smooth surface	ss13	6.145	6.497	12.641	-0.352
Work platform heights	ss14	5.866	5.808	11.675	0.058

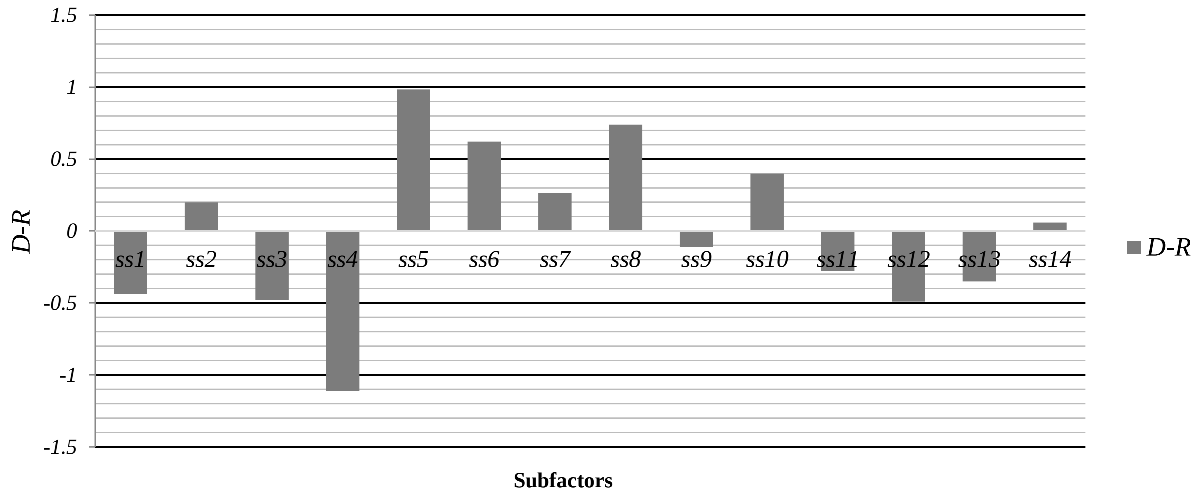

Fig 3: Net cause and effect graph of sub-factors

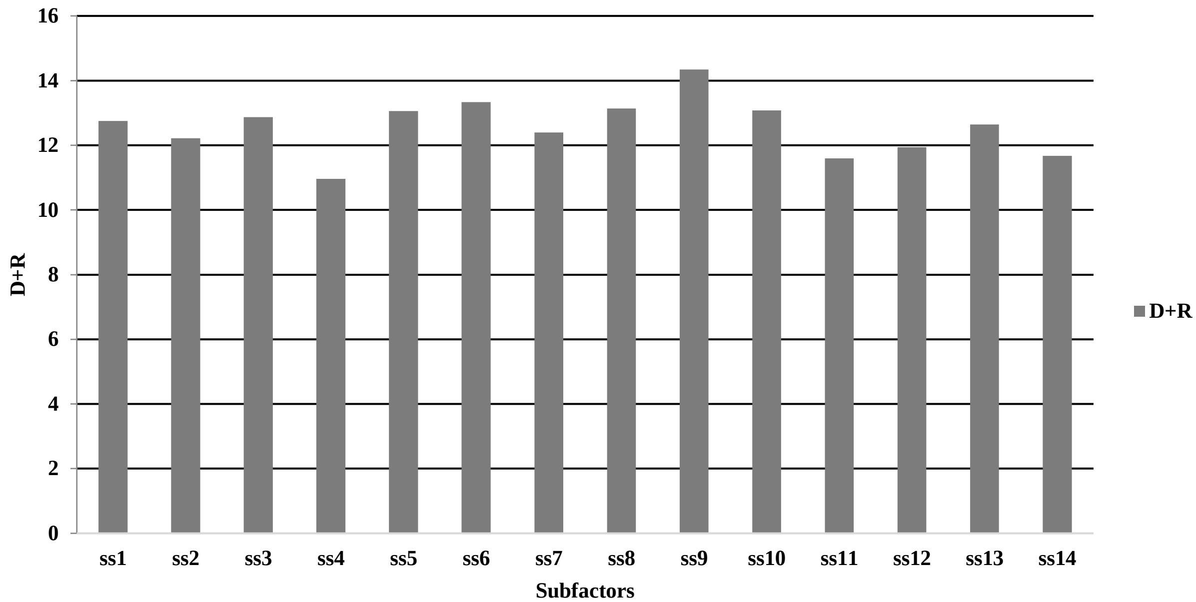

Fig 4: Prominence graph of sub-factors

DISCUSSION

One of the most important findings of this research was to identify the factors affecting the falling from height accidents and also determine the internal relations of these factors using the DIMATEL technique. The results of this research showed that among the main factors, organizational factors were known as causal factors, which indicates importance of the organizational factors and their impact on other effective factors in falling from height accidents.

The safety climate and culture are subset of the organizational culture [44]. Most HSE managers have acknowledged that developing a safety culture is important in order to better control workers' behaviours and protect their safety awareness. Management commitment was explicitly acknowledged as one of the key elements of the organization's success in competitive areas, regardless of the role of certain aspects such as quality, production, job satisfaction and safety. It was also among the effective sub-factors in the safety status and was considered as a subset of organizational factors [32]. Various studies have examined the impact of management commitment on the occurrence of unsafe behaviour and work accidents [45,46]. Nearly all of them had confirmed the claim that the management commitment leads to safe conditions in the workplaces and it is a precious criterion in the projects. In such circumstances, the staff will have a feeling that their

manager's attitude towards the safety is positive and supportive [47].
The senior manager's attention to the safety issues also leads to commitment of the lower levels managers to the plans and guidelines of safety in the organization. Managers at lower levels of management will not pay much attention to the safety plans if they feel that their senior managers are not attentive to safety [48]. Management's attitude also has a huge impact on companies' safety policy [49].
In the present study, safety culture, as one of the organizational sub-factors, had the highest impact and was considered as a causal variable. This issue and its impact on the occurrence of accidents have been the subject of numerous studies in recent years, where the majority of them have confirmed the relationship between the organization's safety culture and the rate of accidents [50,51]. The safety culture affects the behavioural habits of subjects and their beliefs and is highly effective in occupational accidents and injuries [52]. The results of Boughaba *et al.* study showed that the safety culture is effective in the safety function [53].
On the other hands, mutual understanding was another organizational sub-factor that had the highest impact throughout this study and has been identified as a causal variable. Hellman and Hilton stated that mutual understanding is one of the effective factors on the safety status and security of employees in each organization [54]. From Greenberg's viewpoint, mutual understanding occurs when employees believe that their concerns about safety and health are heard and addressed by the managers [55]. Other researchers also found a meaningful relationship between the mutual understanding in the organization and the alignment of activities and compliant employee with the safety instructions and guidelines of organizations [56–58].
The size of a project/organization was another descriptive parameter that has been identified as an organizational sub-factor in this study. The cost of projects operation was considered as a basis for determining the size of the projects or organizations and comparison between each other [59]. In the study conducted by Huang and Hinze (2003), it is found that 28% of falling from height accidents occurred at projects costing less than $ 50,000 so that the possibility of falling from height accidents reduces with increasing the project costs. For example, more than half of the accidents in the US manufacturing industry occur in low-cost projects (cost less than $ 25,000) [43]. Sa *et al.* announced that small companies should pay more attention to work on altitude and accident prevention programs and spend more time on teaching their employees [60]. It can be understood from their study that construction projects of residential complexes have a high risk of high-altitude accidents, which its main reason is the lack of the sufficient budget for training.
The results of DEMATEL technique showed that training hours and psychological/occupational stresses were the most effective individual sub-factors and considered as causal variables. Recent studies have shown that safety educations are the most important tools in preventing of injuries, risks and occupational diseases since it is a prerequisite for improving safety and health at workplace [61,62]. Although many contractors, who are trying to work with minimum labour force and annual cost, always use a large amount of newcomers who have not often received sufficient safety training courses and hence have a high chance of accidents [63]. Previous studies show that the occupational stressors have a major contribution to unsafe behaviours through reduction of concentration, distraction, memory impairment, hesitation in doing activities, decreasing decision-making power, etc. In this regard, the results of the studies attributed 37% of accidents and injuries in the construction industry to the occupational stressful factors [37]. Therefore, identifying stressors related to different workplaces and reducing or eliminating undesirable effects of these factors are the most important measures in the career optimization, increasing the productivity of employees, reducing unsafe acts, and eventually preventing accidents in construction projects [64] .These aims could be achieved by improving the level of occupational health and safety in workplaces and efficiency of the workforces.
Although the DEMATEL technique has been proposed to deal this problem, but it has the limitation that the problems influence must be interactive linearly. Also, this study has explored only one case study in a construction industry, hence conclusions may not generally suit various sectors. As different industries might have various conditions, process characteristics or legislative requirements which affect subject's safe behaviour in the workplace.

CONCLUSIONS

According to the results of the present study, construction projects should always pursue a codified strategy to reduce unsafe environmental conditions. Also, a stress management program along with specialized training should be implemented based on the relevant safety principles for promotion of safety culture in the organization. This solution can play an important role in reducing the falling from height accidents in the construction industries and increasing the management efficiency. Based on the results of this research, organizational factors and their sub-factors have the highest impact on other factors.

Therefore, more attention is needed towards the organizational factors and their dimensions in the construction industry to prevent occurrence of falling from height accidents.

ETHICAL ISSUES

Ethical issues such as plagiarism have been observed by the authors. Also, this study was approved by the regional ethical committee, Iran University of Medical Sciences, Tehran, Iran.

CONFLICT OF INTEREST

The authors declare no conflicts of interest concerning this article.

AUTHORS' CONTRIBUTIONS

The magnitude of each author's contributions is reflected in the author order.

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REFERENCES

[1] Fass S, Yousef R, Liginlal D, Vyas P. Understanding causes of fall and struck-by incidents: What differentiates construction safety in the Arabian Gulf region? Appl Ergon. 2017;58(1):515–26.

[2] Azami-Aghdash S, Sadeghi-Bazargani H, Shabaninejad H, Gorji A. Injury epidemiology in Iran: a systematic review. J Inj Violence Res. 2017;9(1):27-34.

[3] Seifi Azad Mard HR, Estiri A, Hadadi P SAMM. No TitleOccupational risk assessment in the construction industry in Iran. Int J Occup Saf Ergon. 2017;23(4):570-77.

[4] Hoła B, Szóstak M. Methodology of Analysing the Accident Rate in the Construction Industry. Procedia Eng. 2017;172:355–62.

[5] Hinze J, Appelgate LL. Costs of construction injuries. J Constr Eng Manag. 1991;117(3):537–50.

[6] Lipscomb HJ, Glazner JE, Bondy J, Guarini K, Lezotte D. Injuries from slips and trips in construction. Appl Ergon. 2006;37(3):267–74.

[7] Hallowell M. Cost‐ effectiveness of construction safety programme elements. Constr Manag Econ. 2010;28(1):25–34.

[8] Gavious A, Mizrahi S, Shani Y, Minchuk Y. The costs of industrial accidents for the organization: developing methods and tools for evaluation and cost–benefit analysis of investment in safety. J Loss Prev Process Ind. 2009;22(4):434–38.

[9] Chen J-G, Fisher DJ, Krishnamurthy K. Development of a computerized system for fall accident analysis and prevention. Comput Ind Eng. 1995;28(3):457–66.

[10] Hatipkarasulu Y. Project level analysis of special trade contractor fatalities using accident investigation reports. J Safety Res. 2010;41(5):451–57.

[11] Bunn TL, Slavova S, Bathke A. Data linkage of inpatient hospitalization and workers' claims data sets to characterize occupational falls. J Ky Med Assoc. 2007;105(7):313–20.

[12] Hu K, Rahmandad H, Smith‐ Jackson T, Winchester W. Factors influencing the risk of falls in the construction industry: a review of the evidence. Constr Manag Econ. 2011;29(4):397–16.

[13] Shi S, Jiang M, Liu Y, Li R. Risk assessment on falling from height based on AHP-fuzzy. Procedia Eng. 2012;45(1):112–18.

[14] Beltran SL, Vilela RA de G, De Almeida IM. Challenging the immediate causes: A work accident investigation in an oil refinery using organizational analysis. Work. 2018;59(4):617–36.

[15] JM Filho J, Fonseca ED, Lima FPA, Duarte F. Organizational factors related to occupational accidents in construction. Work. 2012;41(Supplement 1):4130–36.

[16] Vosoughi S, Chalak MH, Rostamzadeh S, Taheri F, Farshad AA, Motallebi Ghayen M. A cause and effect decision making model of factors influencing falling from height accidents in construction projects using Fuzzy-DEMATEL technique. Iran Occup Heal. 2019;16(2):65–74.

[17] Liu H-C, Liu L, Liu N. Risk evaluation approaches in failure mode and effects analysis: A literature review. Expert Syst Appl. 2013;40(2):828–38.

[18] Neal A, Griffin MA. A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. J Appl Psychol. 2006;91(4):946-54.

[19] Zhou Q, Fang D, Wang X. A method to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience. Saf Sci. 2008;46(10):1406–19.

[20] Byrd TC. Factors Impacting Safety Climate In A Small, Rural Hospital Setting. Union University; 2014.

[21] Jiang L, Tetrick LE. Mapping the nomological network of employee self-determined safety motivation: A preliminary measure in China. Accid Anal Prev. 2016;94(1):1–7.

[22] Couto JP, Santos FJB, Rabbani ERK. How Time

Constraints Affect Safety Conditions at Construction Sites: Analysis of the Perception of Portuguese Construction Participants. Electron J Geotech Eng. 2017;22(02):563–76.
[23]. Chang B, Chang C-W, Wu C-H. Fuzzy DEMATEL method for developing supplier selection criteria. Expert Syst Appl. 2011;38(3):1850–58.
[24] Gandhi S, Mangla SK, Kumar P, Kumar D. A combined approach using AHP and DEMATEL for evaluating success factors in implementation of green supply chain management in Indian manufacturing industries. Int J Logist Res Appl. 2016;19(6):537–61.
[25] Bacudio LR, Benjamin MFD, Eusebio RCP, Holaysan SAK, Promentilla MAB, Yu KDS, *et al*. Analyzing barriers to implementing industrial symbiosis networks using DEMATEL. Sustain Prod Consum. 2016;7(1):57–65.
[26] Lin Y-T, Yang Y-H, Kang J-S, Yu H-C. Using DEMATEL method to explore the core competences and causal effect of the IC design service company: An empirical case study. Expert Syst Appl. 2011;38(5):6262–68.
[27] Givehchi S, Hemmativaghef E, Hoveidi H. Association between safety leading indicators and safety climate levels. J Safety Res. 2017;62(1):23–32.
[28] Chung C-C, Chao L-C, Chen C-H, Lou S-J. A Balanced Scorecard of Sustainable Management in the Taiwanese Bicycle Industry: Development of Performance Indicators and Importance Analysis. Sustainability. 2016;8(6):518-39.
[29] Tam CM, Zeng SX, Deng ZM. Identifying elements of poor construction safety management in China. Saf Sci. 2004;42(7):569–86.
[30] Khosravi Y, Asilian-Mahabadi H, Hajizadeh E, Hassanzadeh-Rangi N, Bastani H, Behzadan AH. Factors influencing unsafe behaviors and accidents on construction sites: a review. Int J Occup Saf Ergon. 2014;20(1):111–25.
[31] Forteza FJ, Carretero-Gómez JM, Sese A. Effects of organizational complexity and resources on construction site risk. J Safety Res. 2017;62(1):185–98.
[32] Hadikusumo BHW, Jitwasinkul B, Memon AQ. Role of Organizational Factors Affecting Worker Safety Behavior: A Bayesian Belief Network Approach. Procedia Eng. 2017;171(1):131–39.
[33] Fernández-Muñiz B, Montes-Peón JM, Vázquez-Ordás CJ. Safety climate in OHSAS 18001-certified organisations: Antecedents and consequences of safety behaviour. Accid Anal Prev. 2012;45(7):745–58.
[34] Rahimi Pordanjani T, Mohammadzade Ebrahimi A. The effect of employees' management commitment to safety and consciousness on unsafe performance: The mediating role of safety self-efficacy. Heal Saf Work. 2015;4(4):69–80.
[35] Cooper Ph. D MD. Towards a model of safety culture. Saf Sci. 2000;36(2):111–36.
[36] Thayer PW. Justice in the workplace: Approaching fairness in human resource management. Pers Psychol. 1994;47(1):201-02.
[37] M. Goldenhar* L, Williams LJ, G. Swanson N. Modelling relationships between job stressors and injury and near-miss outcomes for construction labourers. Work Stress. 2003;17(3):218–40.
[38] Niskanen T, Louhelainen K, Hirvonen ML. An evaluation of the effects of the occupational safety and health inspectors' supervision in workplaces. Accid Anal Prev. 2014;68(1):139–55.
[39] Beavers JE, Moore JR, Schriver WR. Steel erection fatalities in the construction industry. J Constr Eng Manag. 2009;135(3):227–34.
[40] Cloutier E. The effect of age on safety and work practices among domestic trash collectors in Quebec. Saf Sci. 1994;17(4):291–08.
[41] Epstein Y, Moran DS. Thermal comfort and the heat stress indices. Ind Health. 2006;44(3):388–98.
[42] Saavedra-Robinson LA, Quintana J, Leonardo A, Leal F, Díaz L, Niño M. Analysis of the lifted weight including height and frequency factors for workers in Colombia. Work. 2012;41(Supplement 1):1639–46.
[43] Huang X, Hinze J. Analysis of construction worker fall accidents. J Constr Eng Manag. 2003;129(3):262–71.
[44] Amponsah-Tawiah K, Mensah J. The impact of safety climate on safety related driving behaviors. Transp Res part F traffic Psychol Behav. 2016;40(1):48–55.
[45] McKeon C. Psychological factors influencing unsafe behaviour during medication administration. University of Southern Queensland; 2004.
[46] Vinodkumar MN, Bhasi M. A study on the impact of management system certification on safety management. Saf Sci. 2011;49(3):498–07.
[47] Farh J-L, Cheng B-S. A cultural analysis of paternalistic leadership in Chinese organizations. In: Management and organizations in the Chinese context. Springer; 2000. p. 84–127.
[48] Hsu SH, Lee C-C, Wu M-C, Takano K. A cross-cultural study of organizational factors on safety: Japanese vs. Taiwanese oil refinery plants. Accid Anal Prev. 2008;40(1):24–34.
[49] Håvold JI. Safety culture aboard fishing vessels. Saf Sci. 2010;48(8):1054–61.
[50] Andersen LP, Nørdam L, Joensson T, Kines P, Nielsen KJ. Social identity, safety climate and self-reported accidents among construction workers. Constr Manag Econ. 2018;36(1):22–31.
[51] Casey T, Griffin MA, Flatau Harrison H, Neal A. Safety climate and culture: Integrating psychological and systems perspectives. J Occup Health Psychol. 2017;22(3):341-53.

[52] Chib S, Kanetkar M. Safety culture: the buzzword to ensure occupational safety and health. Procedia Econ Financ. 2014;11(1):130–36.
[53] Boughaba A, Hassane C, Roukia O. Safety culture assessment in petrochemical industry: a comparative study of two Algerian plants. Saf Health Work. 2014;5(2):60–65.
[54] Witt LA, Hellman C, Hilton TF. Management influences on perceived safety. In: American Psychological Society Annual Meeting, San Francisco, CA. 1994.
[55] Greenberg J, Cropanzano R. The social side of fairness: Interpersonal and informational classes of organizational justice. Justice Work Approaching fairness Hum Resour Manag Hillsdale, NJ Lawrence Erlbaum Assoc. 1993;
[56] Bies RJ, Shapiro DL. Interactional fairness judgments: The influence of causal accounts. Soc Justice Res. 1987;1(2):199–18.
[57] Shapiro DL, Brett JM. Comparing the instrumental and value-expressive models of procedural justice under conditions of high and low decision control. In: meetings of the Academy of Management, Miami, FL. 1991.
[58] Shapiro DL. Reconciling theoretical differences among procedural justice researchers by re-evaluating what it means to have one’s views" considered": Implications for third-party managers. 1993;
[59] Cantarelli CC, van Wee B, Molin EJE, Flyvbjerg B. Different cost performance: different determinants?: The case of cost overruns in Dutch transport infrastructure projects. Transp Policy. 2012;22(1):88–95.
[60] Sa J, Seo D-C, Choi SD. Comparison of risk factors for falls from height between commercial and residential roofers. J Safety Res. 2009;40(1):1–6.
[61] Faigenbaum AD, Myer GD. Resistance training among young athletes: safety, efficacy and injury prevention effects. Br J Sports Med. 2010;44(1):56–63.
[62] Vidal-Gomel C. Training to safety rules use. Some reflections on a case study. Saf Sci. 2017;93(12):134–42.
[63] Hinze J, Gambatese J. Factors that influence safety performance of specialty contractors. J Constr Eng Manag. 2003;129(2):159–64.
[64] Blanchard EB, Hickling EJ, Galovski T, Veazey C. Emergency room vital signs and PTSD in a treatment seeking sample of motor vehicle accident survivors. J Trauma Stress. 2002;15(3):199–04.